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THE EFFECT OF FERTILIZERS ON VARIATION IN CORN AND BEANS

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THE data here reported were secured in the summer of 1909 from a field of sweet corn and beans which were fertilized with nitrogen phosphorus and potash separately and in combination after the manner described later. The original purpose of the investigation was to determine if the differences caused by fertilization were in any degree transmitted to succeeding generations. Owing to development of other work it has been impossible to carry this on as planned. It is thought that the data secured may have sufficient interest and value to warrant their presentation.

The plot of land used appeared much exhausted of both plant food and humus. It had previously been used as a raspberry patch. It lay on a gentle southeastern slope sheltered on the opposite side by a belt of woods which, however, was far enough distant to prevent injury from shade or root trespass.

The field was rectangular in shape, 300 feet long and 60 feet wide. It was divided crosswise into twelve plots, each 25 × 60 feet. The fertilizers and their amounts were as follows:

Plot		Lbs.
1.	Nitrate of Soda	12
2.	Check	
3.	Nitrate of Soda Acid Phosphate	12 30
4.	Acid Phosphate	30
5.	Acid Phosphate Sulphate of Potash	30 8
6.	Check	
7.	Sulphate of Potash	8
8.	Nitrate of Soda Sulphate of Potash	12 8
9.	Nitrate of Soda Acid Phosphate Sulphate of Potash	8 20 6
10.	Check	
11.	Nitrate of Soda Acid Phosphate Sulphate of Potash	12 30 8
12.	Manure Sulphate of Potash Acid Phosphate Nitrate of Soda	500 10 40 16

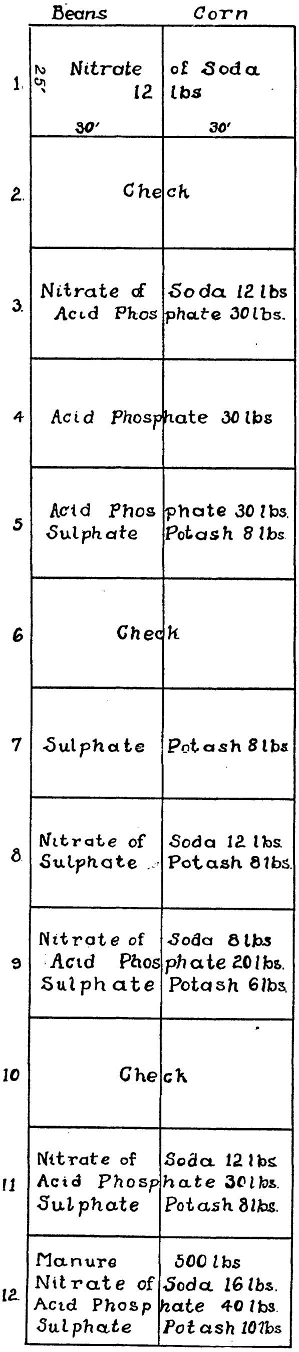

Fig. 1. Plan of Experimental Area.

It is seen that plots 1, 3, 4, 5, 7, 8 and 11 received the several fertilizing materials singly and in combination in what may be called normal amounts of 12 pounds nitrate of soda, 30 pounds acid phosphate and 8 pounds sulphate of potash; plot 9 received all these in considerably smaller amounts; while in plot 12 an excess of the chemicals was applied together with a liberal quantity of ordinary barnyard manure, the idea being to supply here a maximum of the stimulus that ordinary fertilizing materials may be expected to afford. The lower half of the entire plot was planted to corn and the upper half to beans. These facts are graphically shown in Fig. 1. One half of the nitrate and the entire amounts of the other materials were applied broadcast on June 8 and harrowed in. The corn was of the Red Cory variety and was planted June 14, and the Davis white wax beans the next day in drills running lengthwise of the area. Both were thinned where necessary to give the corn space of four inches and the beans three inches. The remainder of the nitrate was applied about three weeks after planting, but the exact date can not be given. The plants were cared for in the usual way and the measurements taken from September 14 to 16, or possibly a few days later. With the corn a record was made of the following: distance from ground to uppermost ear, distance from ground to lowest branch of tassel, and the number of ears formed. Where ear-bearing suckers occurred, the same records were made in such a manner as to indicate their parent stalks. The plants on space of two feet on each end of the plots were omitted in the measurements.

TABLE I

EFFECT OF FERTILIZER ON YIELD OF CORN

Plot	Total Stalks	Barren Stalks, Per Cent.	2-Eared Stalks, Per Cent.	Per Cent. Ear-bearing Suckers
1. Nitrate of soda	241	2.90	1.66	3.32
2. Check	248	43.15	.40	.40
3. Nitrate of soda Acid phosphate	281	5.34	4.27	7.47
4. Acid phosphate	244	44.26	.60	.41
5. Acid phosphate Sulphate of potash	229	35.37	.00	.87
6. Check	251	29.87	.00	.40
7. Sulphate of potash	314	28.03	.00	.64
8. Nitrate of soda Sulphate of potash	269	4.83	3.35	7.06
9. Nitrate of soda Acid phosphate Sulphate of potash ($\frac{2}{3}$ normal)	255	9.80	1.57	5.88
10. Check	225	28.44	.44	.88
11. Nitrate of soda Acid phosphate Sulphate of potash (normal amounts)	241	7.05	3.73	10.37
12. Nitrate of soda Acid phosphate Sulphate of potash (in excess) Manure	248	4.43	10.09	39.92
Av. 3 Checks		33.82	.28	.56

Table I gives figures bearing on the productiveness of the corn, and indicates that the deficient element was nitrogen.[1] There is no indication that the addition of potash or phosphorus decreased the number of barren stalks at all, nor did either alone increase the number of two-eared stalks of ear-bearing suckers, though there appears to be considerable benefit from each when applied with nitrogen, and still more when all three are supplied. The addition of manure results beneficially in all ways, possibly on account of its physical action as well as by the direct addition of plant food.

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[1] While the discussion following is in terms of the elements of fertility, it is of course possible that other carriers of the same elements might have given different results. It has seemed simpler to express the matter in terms of the elements and with a full reading of the text no misunderstanding on this point is possible.

TABLE II

VARIATION IN STATURE OF CORN PLANTS

Plot	Ear Height			Stalk Height		
	Mean	Standard Deviation	Coefficient of Variability	Mean	Standard Deviation	Coefficient of Variability
1. Nitrate of soda	11.61 ±.19	4.20 ±.13	36.18 ±1.26	46.68 ±.25	5.80 ±.18	12.42 ±.40
2. Check	11.78 ±.19	3.36 ±.14	28.52 ±1.23	45.26 ±.29	6.72 ±.20	14.84 ±.46
3. Nitrate of soda Acid phosphate	13.18 ±.17	4.39 ±.14	33.37 ±1.07	50.42 ±.25	6.14 ±.18	12.18 ±.35
4. Acid phosphate	12.00 ±.20	3.39 ±.14	28.25 ±1.24	44.76 ±.29	7.07 ±.22	13.56 ±.48
5. Acid phosphate Sulphate of potash	11.69 ±.19	3.36 ±.13	28.75 ±1.21	43.07 ±.31	7.03 ±.22	16.33 ±.53
6. Check	11.64 ±.16	3.22 ±.12	27.66 ±1.07	45.71 ±.29	6.74 ±.20	14.72 ±.45
7. Sulphate of potash	12.61 ±.17	3.67 ±.12	29.02 ± .99	47.02 ±.27	7.16 ±.19	15.28
8. Nitrate of soda Sulphate of potash	13.53 ±.18	4.15 ±.12	30.45 ± .96	50.45 ±.28	6.84 ±.22	13.56 ±.40
9. Nitrate of soda Acid phosphate Sulphate of potash ($\frac{2}{3}$ normal)	13.02 ±.19	4.25 ±.13	32.64 ±1.13	49.49 ±.30	7.05 ±.21	14.25 ±.43
10. Check	10.33 ±.16	3.28 ±.12	31.75 ±1.31	42.12 ±.29	6.45 ±.21	15.31 ±.50
11. Nitrate of soda Acid phosphate Sulphate of potash (normal amounts)	13.37 ±.18	4.05 ±.13	30.29 ±1.05	51.38 ±.30	6.98 ±.22	13.59 ±.44
12. Nitrate of soda Acid phosphate Sulphate of potash (in excess) Manure	15.36 ±.22	4.97 ±.15	32.36 ±1.10	56.65 ±.31	7.25 ±.22	12.80 ±.38
Av. 3 Check	11.25	3.29	29.31	44.36	6.64	14.96

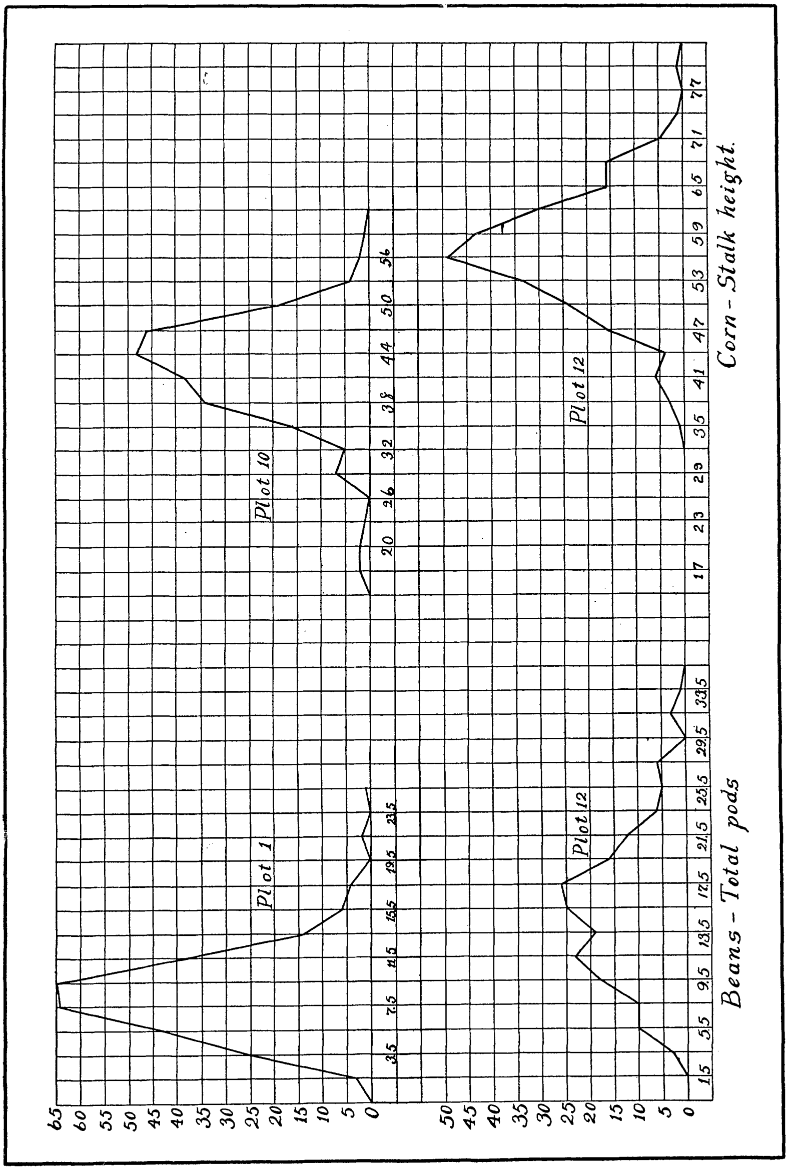

FIG. 2. Variation in Beans and Corn.

Table II shows the variation in stature of the corn plants. With respect to ear height it is seen that the addition of the mineral elements, especially if nitrogen was also supplied, apparently raised the mean. It will be remembered that ear height is taken to the uppermost ear in two-eared stalks, and a comparison with Table I indicates that the ear height is significantly greater only where there is a considerable percentage of two-eared stalks, making it very probable that none of the fertilizers influenced in any marked degree the height of the ear on single-eared stalks, or of the lower ear where two were present.

The differences in variability of ear height so far as they are significant are probably to be referred to the same cause, an increased number of two-eared stalks resulting in greater variability, as would be expected.

TABLE III

VARIATION IN YIELD OF BEANS

Plot	Pods per Vine		Coefficient of Variability
	Mean	Standard Deviation	
1. Nitrate of soda	8.63 ±.14	3.49 ±.10	40.441 ±1.36
2. Check	4.81 ±.14	3.18 ±.10	66.11 ±3.21
3. Nitrate of soda Acid phosphate	9.62 ±.23	5.25 ±.16	54.42 ±2.43
4. Acid phosphate	7.61 ±.18	3.94 ±.13	51.77 ±1.60
5. Acid phosphate Sulphate of potash	10.71 ±.25	5.05 ±.17	47.15 ±1.93
6. Check	9.13 ±.22	4.34 ±.15	47.53 ±2.02
7. Sulphate of potash	10.09 ±.18	3.76 ±.13	37.26 ±1.41
8. Nitrate of soda Sulphate of potash	9.82 ±.16	3.59 ±.11	36.56 ±1.30
9. Nitrate of soda Acid phosphate Sulphate of potash (⅔ normal)	12.26 ±.21	4.39 ±.15	35.79 ±1.36
10. Check	6.75 ±.16	2.96 ±.11	43.85 ±1.93
11. Nitrate of soda Acid phosphate Sulphate of potash (normal amounts)	13.20 ±.21	5.01 ±.15	37.95 ±1.30
12. Nitrate of soda Acid phosphate Sulphate of potash (in excess) Manure	15.34 ±.30	6.09 ±.22	38.38 ±1.54
Av. 3 Check	6.89	3.49	52.49

There is little evidence that either of the mineral elements alone or both together increased the stature of the whole plant, though nitrogen did have this effect. Nitrogen together with either phosphorus or potash had a more pronounced effect, and when all three were applied together in plot 11 the stature was still greater. Increasing the amounts of the commercial fertilizers and adding manure in plot 12 gave still taller corn.

The standard deviation is apparently increased by the mineral elements either alone or together, while nitrogen operates to lessen this measure of variability. When all are used together both influences seem to operate and the standard deviation is increased, but not so much as with the mineral elements alone. The increase of the standard deviation where considerable amounts of complete fertilizer is added is not in proportion to the increased mean, and the coefficient of variability is lessened.

It was not found possible to make any measurements bearing on the vegetative vigor of the bean plants; the only figures available are those of yield as measured by the total number of pods on each plant. Table III indicates that potash was most effective in increasing the mean number of pods per vine, though it will be remembered that this element was of the least avail with corn. Nitrogen seems next, and there is a possible beneficial effect from phosphorus. When all are applied the average is higher even on the plot receiving only two thirds the normal amount. Increasing the quantity of chemicals and adding manure increase still further the yield. The results are not as consistent as in the case of stalk height of corn. This variability in yield finds further expression in the larger variation within each plot as expressed by the coefficients of variability which are nearly three times as great as those for stalk height of corn.

The effect of the single elements on the standard deviation is not very clear, but it seems that two or more together increase it, but if nitrogen is present this increase is not in proportion to the increased mean and the coefficient of variability is lessened. There is some indication that potash has a similar effect. Owing to the uncertainty of pod setting a great many data are necessary in order to give definite information on these points.

In Fig. 2 is shown graphically the difference in the effect of the fertilizer on yield of beans and stalk height of corn. This shows that fertilizers greatly extended the range of variation of total pods per vine; the minimum is only slightly raised, but there are many more plants with a considerable number of pods and the maximum number of pods per vine too is markedly increased. There is a greater "scatter" to the distribution. With the stalk height of corn the "scatter" is not much increased, but the whole polygon is moved bodily to a higher position. The fertilizer had a direct effect on every stalk of corn, increasing its stature, but it had little effect on the productiveness of a few of the bean plants, though increasing that of most of them.

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